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FOREIGN TECHNOLOGY DIVISION

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By

Chang Feng-Fang

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FOG PREVENTION IN AERONAUTICS

Chang Feng-Fang

Abstract

It is well known that fog can seriously reduce visibility and interfere with the takeoff and landing of airplanes. Due to the interior and exterior temperature difference, fog can form on the cabin window glass, the instrument panel glass, the helmet shield of pilots and astrunauts, and the lens of high speed photographic cameras. This article is a discussion of various fog prevention measures.

* * *

We are all familiar with fog in the natural environment and aware of the poor visibility it causes and the serious obstruction on aircraft takeoff and landing. In addition to the naturally occurring fog, there are also fog condensation phenomena in our daily life, for instance, people wearing eye glasses enter the bath room and the glasses fog up immediately. In winter, travellers on a bus or train will find the scenery outside the windows very foggy. When we look into the mirror which has just been breathed upon, the image is very unclear.

What causes the condensation of fog? This is because of the temperature difference between the interior and the surface of the glass causes the water vapor in air to condense into discontinuous tiny water droplets when the surface temperature is lower than the dew point temperature of air. These little water droplets will scatter and diffract light and interfere with vision. In the case of the train, the temperature

and humidity inside is high and the atmosphere temperature outside the train is low, a temperature difference thus exists between the inner and outer surfaces of the window glass. Fog forms when the temperature difference is large enough to cause condensation of water vapor on the glass surface.

Similar effects are observed on aircraft and spaceships -- fog forms on their cabin window glass, instrument panel, and pilot and astronaut helmet shields, lenses of high speed photographic cameras and the windows of spacecraft equipment capsule.

Damages Caused by Fog

One can easily wipe the condensation off the glass window or eye glasses, but cannot do the same for aircraft or spaceship window glass. Since aircraft are controlled by observing the instruments, a foggy instrument panel glass will distort the readings optically or cause the instruments to be totally invisible. Fig. 1 shows the comparision between the situations with and without the interference of fog.

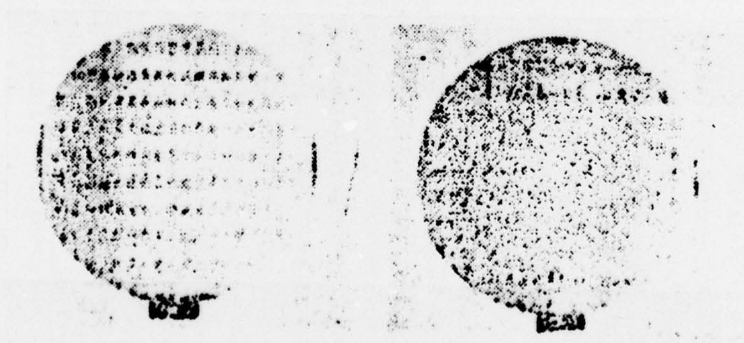

Fig. 1 Comparison observation; left: without fog; right: with fog.

A fogged up face mask causes serious difficulties to a parachuting pilot or an astronaut working outside the space module. It is equivalent to the loss of the service of one's eyes. It has been reported that certain scheduled research projects were aborted on the Apollo spaceship launched by the American Imperalists because of the fog problem on instrument panels. Fog prevention is therefore indispensable in aeronautics and space missions.

Methods of Fog Prevention

Many techniques were investigated in the past thirty years. Currently, the following three methods are most popular:

(1) Heating: Resistance wire may be imbedded in the glass or an electrically conducting thin film may be vacuum deposited on the glass surface. Heat will prevent the condensation of water vapor into small deoplets. The disadvantage of this method is the poor degree of transparency -- less than 75 per cent, also, a suitable electric power source is required which adds complications.

(2) Vacuum Seal: The interior of gauges or instruments may be pumped down and then sealed off so that moisture, the source of fog, is removed. This method requires complicated workmanship and its use is very restricted under most cases.

(3) Water absorbing coating: A thin layer (less than 200 micron meter) of water absorbing and transparent film is coated on the glass surface. This coating will absorb the water moisture in the air and keep the transparency of the glass. The coating method is widely used since it requires no electrical system and the manufacture process is relatively simple. The rest of this article will emphasize this method.

Materials for Water Absorbing Coating

This fog preventing material may be considered a mixture of two groups: A is the water repelling base group and B is the water absorbing base group. B group has a strong adhesion to water and it can greatly reduce the surface tension of water and make the adhesion angle very small. Once the water vapor condenses on such treated glass surface, the condensed water will quickly spread into a uniform and continuous water film. This water film is as clear as it can be and in no way harms the transparency of the glass. However, since the B group is strongly water attracting, it is also highly dissolvable in water the the film will be washed away after absorbing a large amount of water. In this respect, group A has a complementary effect: since group A is water repelling and indissolvable in water (like paraffin), it prohibits the solubility of group B to some extent. With the combination of both groups, the material possesses both the water absorbing fog preventing property and the resistance to wash out. The ratio of the two groups must be optimum in a good fog prevention material.

Desired Features: Fog prevention materials for glass should satisfy the following requirements: The material must have sufficient water absorbing ability and the absorbed water should form a uniform and continuous film on the glass surface so that optical aberration will not be present, that is, there will be no distortion of an object's shape observed through the glass. Its operating temperature range should be wide enough to cover the temperature variations abord an aircraft; it should not dissociate or change color at high temperature and should not form frost at low temperature. It should be durable for long term service and be scratch resistant. It also needs to be stain resistant and

repellant to dust and other light particles in the air.

Materials used: Since fog prevention relies on the water absorbing properly which is shared by many materials, surface activator and water absorbing high polymer compounds are used most often. Materials in these categories include the following: sulfahydrocarbonates (alkyl sulfonate, alkyl aromatic sulfonate, etc.), ethylene oxide derivatives (alkaneoxyl polybutylene imine-60, -80), polyhydroxyl compounds (polyvinyl, polyvinyl acetol, glycerin, polyglycol, methoxyl polyglycol, etc.) polyethers (alkyl polyphenolether, siloxane, and other polyether polymers), B-cellulose, D-cellulose, and pectin.

Although surface activators have some fog prevention abilities, they are water soluble and can easily be washed out after prolonged use and periodic exposure to high humidity. Cellulose is unstable to heat and light and tends to turn yellow and brittle after long periods of time. Pectin is susceptable to bacteria errosion after it absorbs water. Glycerol polyether is hard to dry and therefore susceptable to contamination. There are also low transparency compounds containing pigment. Among the many water absorbing high polymer compounds, after extensive tests, polyvinyl was found to be an effective coating material for fog prevention. The large number of hydroxide groups in its molecular chain tend to combine with the hydroxide in water molecules and form many hydrogen bonds. This shows up as a strong ability to absorb water and superior fog prevention performance. In the meantime, the transparency of this coating material is high enough so that the transparency of the glass is not degraded by the coating. Its shortcomings are turning soft after absorbing large amounts of water, susceptability to scratch damage and the tendency

to become dirty from adhered dust in the atmosphere. Thus polyvinyl alone is still not the ideal material.

In order to keep the desirable feature of polyvinyl and correct its shortcomings, boric anhydride, phosphoric acid, phosphite, hydrogen perphosphate, and compounds containing carbonyl and hydroxyl are used to react with some of the hydroxyl in polyvinyl to achieve a suitable balance between these two groups and therefore control the water absorbing performance. This treatment has the dual advantage of improving the fog prevention durability and the strength and comtamination resistance of polyvinyl. The improved adhesion after treatment also prevents peeling from the glass surface.

Method of Application: Application method depends upon the location, the material and the fog condensation conditions. The following two methods are used most often:

(1) Fog prevention material is made into thin films of a thickness 2 - 200 micron. Such films, known as fog resistant paper or transparency sheets, can be cut to size and applied on to the glass surface, as shown in Fig. 2.

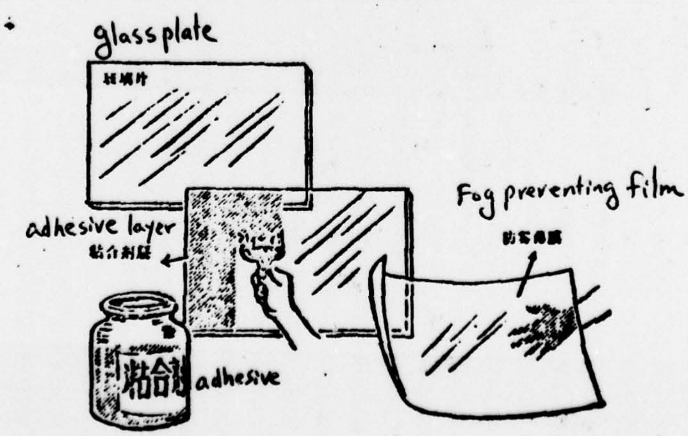

Fig. 2 Application of fog resistant paper

(2) Fog preventing materials can be shaped directly into surface plates containing a diffusive agent which dissoliates into a wetting agent upon contact with water or moisture in the air. The wetting agent forms on the surface of the plate and after it is dissolved and washed away by water, more will diffuse from the interior of the plate to the surface and keep the wetting effect. Thus the fog prevention ability is maintained for a prolonged period of time.

Another method should also be mentioned, whereby the fog prevention material is mixed with water and solvent such as ethyl alchol to form a solution. Small amounts of some adhesion agent and hardener are added and the solution can then be sprayed or spread on the glass surface. The disadvantage of this method is nonuniformity. The best methods of application are the centrifuge method and the dip method. In the centrifuge application, the glass plates are fixed on a motor rotating with a certain angular speed, the fog prevention solution is then dripped on the glass to form a thin film. In the dip method, the glass plates are dipped into a solution and then pulled out with a uniform speed. The films obtained by these two methods are quite uniform and free from optical aberration. The methods are simple enough for wide application.

So far, the most widely used technique in for prevention is still the application of fog resistant paper. In recent years, direct treatment of glass surface has also been investigated to alter the molecular structure of the glass surface so that it becomes water absorbing. This method has unique merits under some circumstances.

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